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13. ABSTRACT (Maximum 200 words) DURING JANUARY, 1989, AN INVESTIGATION WAS CONDUCTED TO DETERMINE THE PRESENCE AND THICKNESS OF LIGHT, NON-AQUEOUS PHASE LIQUID (LNAPL) IN MONITORING WELLS IN SECTIONS 1 AND 2. THIS REPORT PRESENTS A BRIEF DESCRIPTION OF WORK COMPLETED, DATA COLLECTED, AND GENERAL CONCLUSIONS BASED ON THE DATA GENERATED. THE INVESTIGATION INCLUDED DRILLING AND INSTALLATION OF SEVEN MONITORING WELLS AND THE MEASUREMENT OF THE LNAPL THICKNESS IN THE SEVEN NEW WELLS AND FIVE EXISTING WELLS. LNAPL IS COMPOSED PRIMARILY OF DCPD AND BCHPD WITH SMALL AMOUNTS OF C6H6, MEC6H5, AND XYLEN. THE CONCLUSIONS DERIVED FROM THE INVESTIGATION ARE THAT LNAPL IS: 1. RESTRICTED TO THE DENVER FORMATION 2. LIMITED IN ITS LATERAL EXTENT AND HAS A MAXIMUM THICKNESS OF 1.4 FEET 3. POTENTIALLY AN ACTIVE SOURCE OF GROUND WATER CONTAMINATION. IT IS RECOMMENDED THAT THE LNAPL PLUME BE INCLUDED IN THE REMEDIATION OF OTHER CONTAMINATION SOURCES IRA.				
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**REPORT OF THE INVESTIGATION OF THE  
LNAPL PLUME NEAR TANK 464A,  
SECTION 1, RMA**

**Prepared By  
MK-Environmental Services**

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## EXECUTIVE SUMMARY

During January, 1989, an investigation was conducted to determine the presence and thickness of light, non-aqueous phase liquid (LNAPL) in monitoring wells in Sections 1 and 2. Results of the investigation indicate the presence of a significant thickness of LNAPL in an area adjacent to and west of Tank 464A in Section 1. In May, 1989, an investigation was initiated to more adequately characterize the lateral and vertical extent as well as determine the composition of the LNAPL plume.

The elements of the investigation near Tank 464A included drilling and installation of seven monitoring wells, measurement at regular time intervals of the LNAPL thickness in the seven new wells and five previously-existing wells nearby, and sampling and laboratory analysis of three LNAPL samples. From completion of these activities, the information acquired included a more detailed definition of subsurface geology, better definition of the local water table configuration, definition of the downgradient extent of and lateral variation in the thickness of the LNAPL, and the presence and approximate fraction of several compounds in the LNAPL.

The conclusions derived from the investigation are that the LNAPL plume is restricted to the Denver Formation sediments, has a limited lateral extent approximated by the presence or absence of LNAPL in wells and a maximum thickness in monitoring wells of approximately 1.4 feet, and is composed primarily of dicyclopentadiene and bicycloheptadiene derivatives with minor percentages of benzene, toluene, and xylene. Further, it is reasonable to assume that LNAPL is present in both the saturated and unsaturated zones in this area and serves as an active source of groundwater contamination in Sections 1 and 2. Since an active source will contribute to increasingly widespread contamination at increasing concentration levels in groundwater,

it might be cost-effective to remediate the site under the Remediation of Other Contamination Sources IRA, as opposed to delaying remediation until after the final ROD. Therefore, the LNAPL plume should be included, together with the dissolved plume in Sections 1 and 2, in the development and evaluation of remedial alternatives for the South Tank Farm Plume.

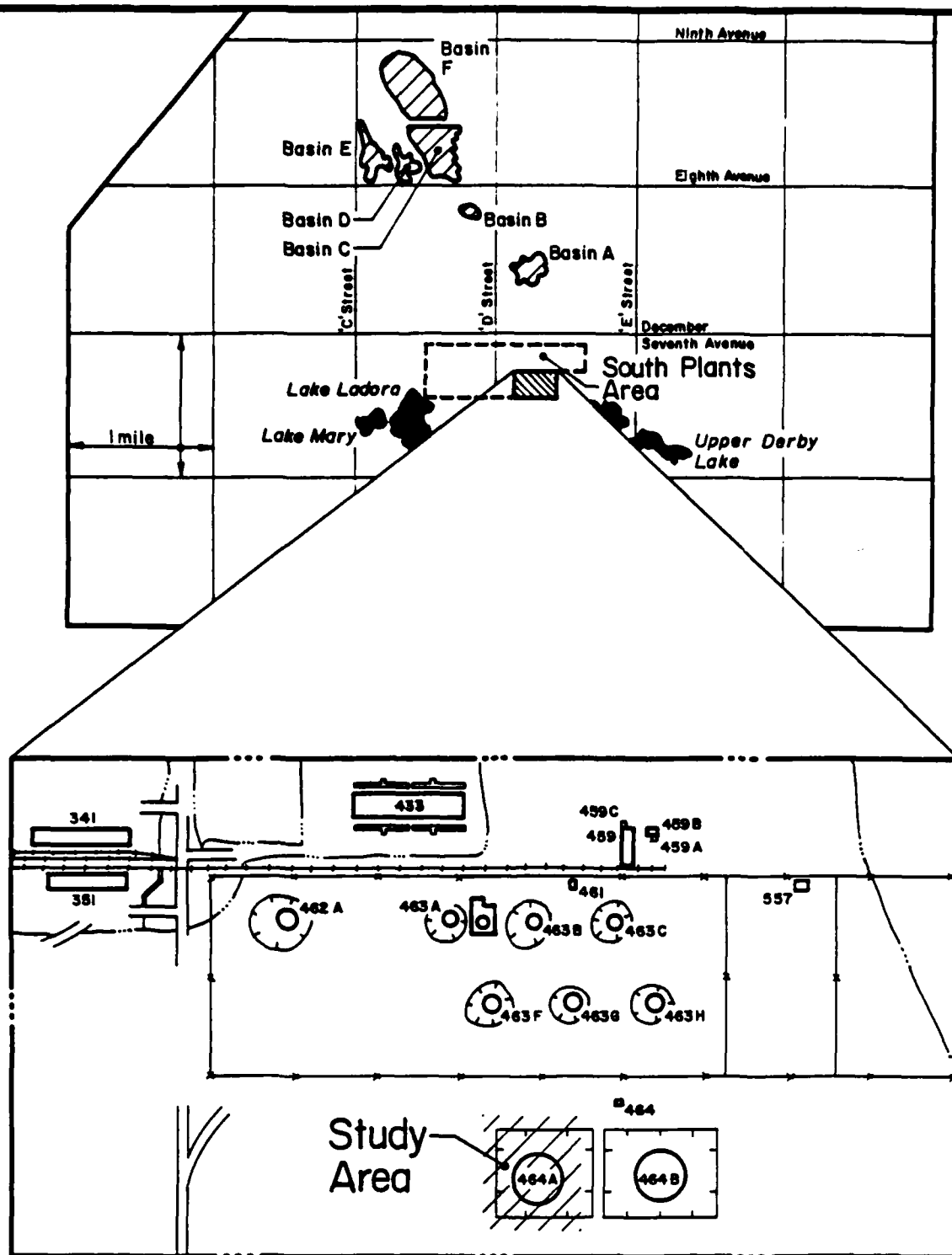
## 1.0 INTRODUCTION

An area located adjacent to and west of Tank 464A was investigated as a potential active source of groundwater contamination in portions of Sections 1 and 2. The investigation was initiated in response to the detection of light non-aqueous phase liquids (LNAPL) in existing monitoring wells located adjacent to Tank 464A in January 1989. The area included in this investigation is presented on Figure 1.

Results of previous groundwater sampling and analyses indicate that a plume of contaminated groundwater containing numerous organic compounds is present in the western portion of Section 1 and the eastern portion of Section 2 (USATHAMA Database 1989). This northeast-southwest trending plume is thought to be the result of multiple sources, one or more of which may be located in the vicinity of the South Tank Farm. Analyses of samples collected from monitoring wells show that an area located proximal to Tanks 464A and 464B contains higher concentrations of xylene, benzene, toluene, dicyclopentadiene and bicycloheptadiene relative to the area located further upgradient. These data indicate that Tanks 464A and 464B may have been a source of these contaminants.

Due to the high contaminant concentrations detected in many of the monitoring wells sampled in the South Plants Area, an investigation was initiated during January 1989 to determine whether LNAPLs could be present in the existing Shell wells located in Sections 1 and 2. The data derived from this initial investigation indicated the presence of LNAPLs in a limited area proximal to Tank 464A. The location of the LNAPL and the ground-water data suggested that the LNAPL may be comprised primarily of dicyclopentadiene and bicycloheptadiene, which are compounds associated with previous use of Tank 464A.





north

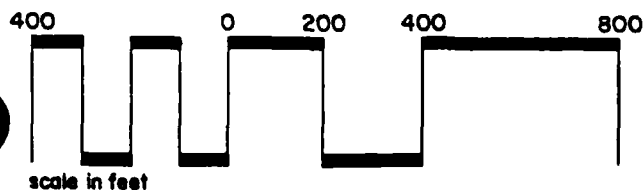


Figure: I

## Study Area Location Map

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From results of the January 1989 investigation, an investigation to more adequately define the LNAPL plume proximal to Tank 464A was initiated during May, 1989. The investigation included:

- . Drilling and complete installation of seven two-inch diameter monitoring wells;
- . Limited development of the newly constructed monitoring wells;
- . Measurement of LNAPL thickness in the newly constructed two-inch diameter wells and five nearby existing four-inch diameter wells; and
- . Sampling and laboratory analysis of the LNAPL from the two monitoring wells in which a significant thickness of LNAPL was detected.

This report presents a brief description of work completed, data collected, and general conclusions based on the data generated.

## 2.0 SCOPE OF WORK

### 2.1 DRILLING AND WELL INSTALLATION

Borehole drilling and monitoring well construction was undertaken at eight locations within the berm west of Tank 464A. The well locations were chosen in an effort to obtain estimates of the lateral and vertical extent of the LNAPL plume. The total depth of each well was established during drilling such that the top of screen would be above the historic high water table and the screened interval penetrated more than 10 feet of the uppermost unconfined aquifer. The locations of these wells are presented on Figure 2.

Drilling was accomplished by Arrow Drilling Company of Golden, Colorado using 7-5/8-inch outer diameter hollow-stem auger. A five foot split sample barrel was utilized to obtain continuous samples over the entire borehole depth. All samples and drill cuttings were containerized after geologic descriptions were obtained. Each borehole was continuously logged by a qualified geologist during drilling.

Upon completion of drilling, each well was installed according to standard procedures. The wells were then developed by hand surging and bailing.

### 2.2 MEASUREMENT OF FLUID THICKNESS

Measurements were made of the depths to the top of the LNAPL and groundwater in the seven newly-constructed wells and five existing wells. All measurements were referenced from the top of casing. Depth to the top of the LNAPL was obtained by standard liquid level measurements using steel tape and chalk. Depth to groundwater was obtained by standard liquid level

01540

01554

01543

01553

01544

01545

01575

01562

01546

01574

01539

01561

TANK  
464 A

01552

## Legend

⊕ Shell Well

○ Abandoned Well

● New Well

— Berm

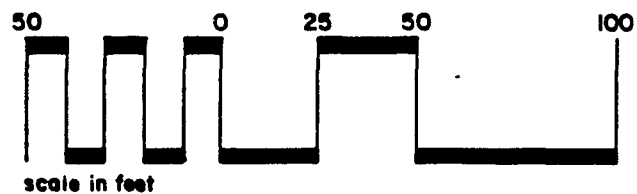


Figure: 2

## Well Location Map

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measurements using steel tape and water paste. The LNAPL thickness in the well was obtained by subtracting the depth to LNAPL from the depth to groundwater.

### 2.3 LNAPL SAMPLING AND ANALYSES

A total of three samples of the LNAPL were collected. One 40 milliliter sample was collected from Well 01546 and two 40 milliliter samples were collected from Well 01553. One of the two samples from Well 01553 was collected as a duplicate sample to assist in determining variability within the fluid column. The samples were analyzed using GC/MS techniques.

The wells that were sampled contained at least one foot of LNAPL. The samples were obtained using a bottom-filling, Teflon bailer. A nylon rope calibrated in feet was used to lower the bailer. The LNAPL/groundwater interface was not penetrated during sampling. The sample was transferred from the bailer to a 40 ml glass vial. The samples were then packaged and shipped to Pacific Analytical Laboratory of Carlsbad, CA for analyses of each organic compound in the fluid.

### 3.0 RESULTS

#### 3.1 DRILLING AND WELL INSTALLATION

The hydrogeologic data generated from logging each borehole and installing each well are presented as Appendix A. The location coordinates, ground elevation, TOC elevation, screen top, and screen bottom are listed for each well in Table 1.

Borehole depths ranged between 26.3 and 29.0 feet below ground surface. Information obtained from the field borehole logs indicate that the alluvial sediments present within the study area are approximately 2.5 to 6.5 feet thick. The sediments are comprised of a sandy clayey silt at Wells 01543 and 01544, and a very fine to very coarse grained silty sand with minor clay at the remaining well locations. There was no evidence of alluvial contamination other than an interval of silty sandy clay containing a black oily substance from 1.0 to 2.5 feet found at Well 01545.

The Denver Formation lies directly below the alluvial sediments, with the top of the formation occurring at depths ranging from 2.5 to 6.5 feet. The formation is comprised of a highly to moderately weathered, highly to slightly fractured, interbedded sandy claystone and siltstone with minor clayey sandstone lenses. Depths to fluid noted during drilling ranged from 12 to 15 feet. From this, it appears that the water table resides entirely in the Denver Formation in the study area. Subsurface contamination of the sediments below the water table was noted during the drilling of Wells 01544 and 01546, when LNAPL appeared at the borehole collar. LNAPL also appeared at the ground surface while pulling augers from Wells 01543 and 01546.

For installing each of the wells, 20 feet of 2-inch diameter PVC with 0.02-inch slotted screen was used. The top of the screen extended at least four feet and no more than seven feet above

**TABLE 1**  
**WELL CONSTRUCTION INFORMATION**

<u>Well No.</u>	<u>Northing</u>	<u>Easting</u>	<u>Ground Elevation</u>	<u>TOC Elevation</u>	<u>Screen Top</u>	<u>Screen Bottom</u>
01543	178159.48	2184429.72	5266.06	5267.94 5268.51*	6.3	26.3
01544	178116.48	2184400.58	5266.55	5268.37	8.0	28.0
01545	178102.77	2184359.08	5267.32	5268.98	8.2	28.2
01546	178076.07	2184384.38	5265.81	5268.30	7.2	27.2
01561	178049.59	2184409.71	5265.99	5267.54	8.1	28.1
01562	178089.49	2184405.38	5267.18	-	-	-
01574	178061.11	2184366.53	5266.64	5267.55	8.7	28.7
01575	178093.20	2184405.21	5267.29	5269.05	8.0	28.0

\* Protective casing extends above the TOC measuring point. As a result, accurate measurements from the TOC measuring point could not be obtained. A reference point marked on the protective casing was used.

the depth to water noted during drilling. Well 01562 was abandoned during construction due to screen collapse and subsequent sand infilling of the casing. Abandonment was achieved by removing the broken portion of the screen and casing and grouting the borehole to the surface.

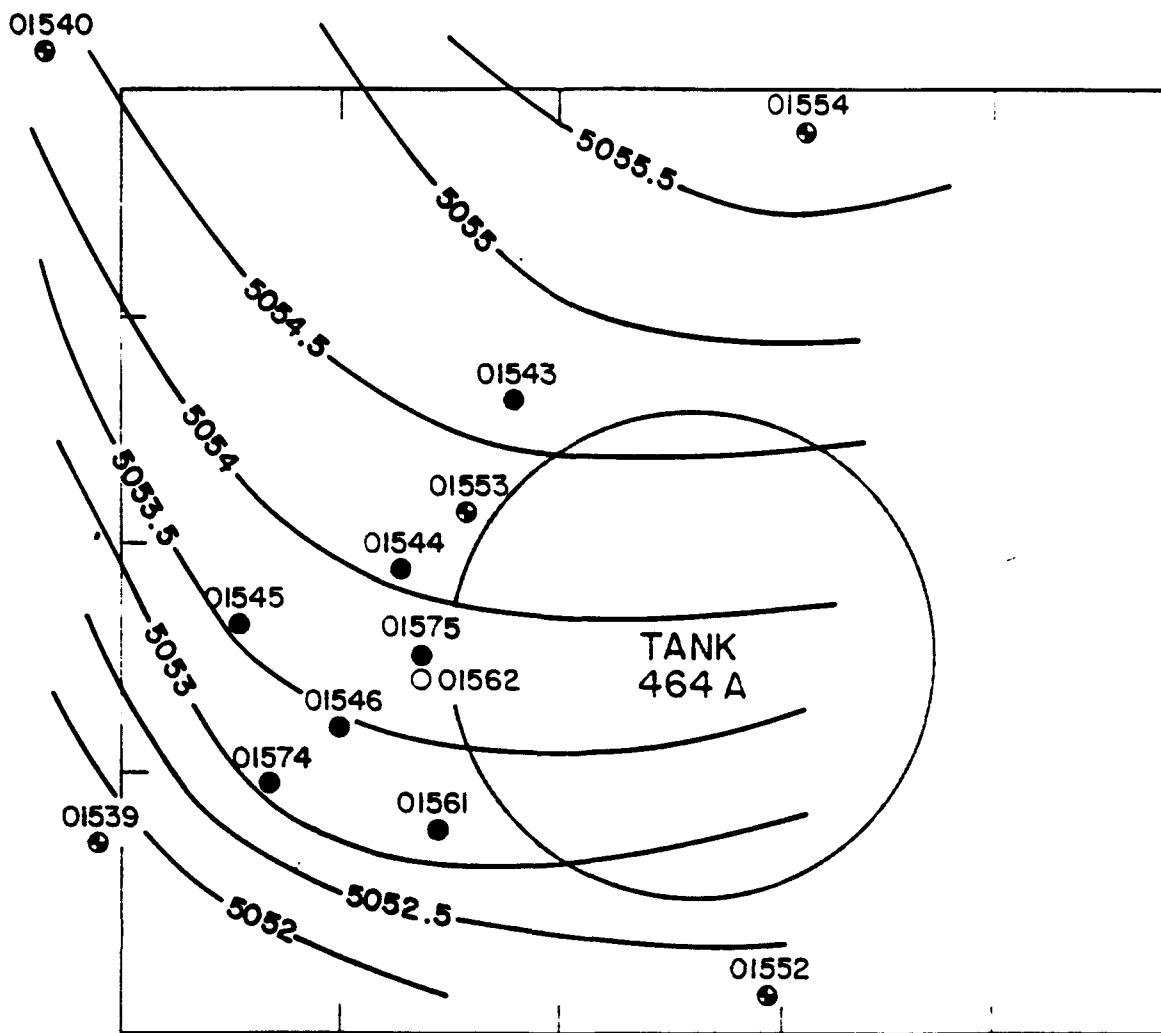
Each well was developed by hand surging and bailing one borehole volume. It is acknowledged that this manner of development did not purge all of the collected sediments from the bottom of the screened interval. However, because LNAPLs were generated during development and the wells were used for the monitoring and collection of LNAPLs exclusively, the manner of development is believed to be adequate for this study.

### 3.2 MEASUREMENT OF LNAPL THICKNESS

The depths to the LNAPL and groundwater were initially measured on a daily basis, then on a bi-weekly basis in the seven newly constructed wells and five existing wells. Tables 2 through 5 present data collected on June 7, June 12, June 29, and July 11, respectively. Depths to the LNAPL were not measured in Wells 01540, 01552, and 01553 prior to June 16, 1989 because no LNAPL was detected in these wells during the initial January 1989 survey. Figures 3 and 4 present the water table configuration and the thickness of LNAPL as measured on June 29, 1989, respectively. A review of the tables and figures indicates the presence of LNAPL in Wells 01546, 01553, 01574, and 01575. A shallow southwest trending gradient of the water surface exists in the study area. It appears that Well 01574 may define the downgradient extent of the LNAPL.

A review of the construction data of the existing Shell wells indicates that the top of screen in Wells 01539, 01553, and 01554 does not extend above the water table. Therefore, the





## Legend

- ⊕ Shell Well
- Abandoned Well
- New Well
- Berm
- 5055— Water Level Contour

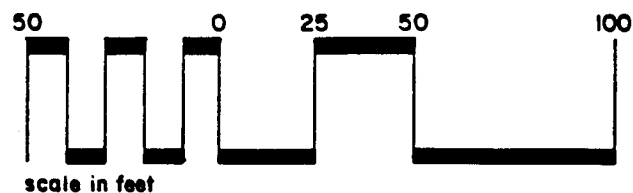


Figure: 3

## Water Table Contour Map

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01540  
●  
N.D.

01554  
●  
N.D.

01543  
●  
N.D.

01553/1.43'

01544  
●  
N.D.

01545  
●  
N.D.

01575/0.13'

01546/1.20'

01574/0.01'

01561  
●  
N.D.

01539  
●  
N.D.

TANK  
464 A

01552  
●  
N.D.

## Legend

● Shell Well

○ Abandoned Well

● New Well

— Berm

● 1.20' LNAPL Thickness

N.D. Not Detected

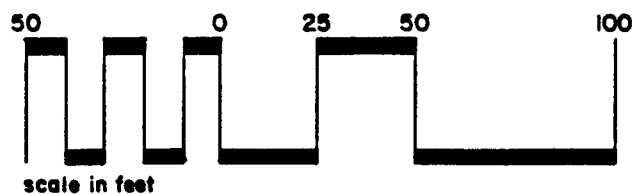


Figure: 4

## LNAPL Thickness

June 29, 1989 Data

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TABLE 2

JUNE 7, 1989 LNAPL THICKNESS

<u>Well No.</u>	<u>Depth to NNAPL</u>	<u>Depth to Water</u>	<u>LNAPL Thickness</u>	<u>Measuring Point</u>
01539	21.93'	21.93'	0.00'	TOC
01540	-	15.36'	-	TOC
01543	13.13'	13.14'	0.01'	TOC
01544	12.98'	13.00'	0.02'	TOC
01545	14.11'	14.11'	0.02'	TOC
01546	12.95'	14.01'	1.06'	TOC
01552	-	17.03'	-	TOC
01553	14.44'	16.10'	1.66'	TOC
01554	-	13.75'	-	TOC
01561	12.11'	12.11'	0.00'	TOC

TABLE 3

JUNE 12, 1989 LNAPL THICKNESS

<u>Well No.</u>	<u>Depth to NNAPL</u>	<u>Depth to Water</u>	<u>LNAPL Thickness</u>	<u>Measuring Point</u>
01539	22.10'	22.10'	0.00'	TOC
01540	-	15.28'	-	TOC
01543	13.45'	13.45'	0.00'	TOC
01544	13.67'	13.67'	0.00'	TOC
01545	14.67'	14.67'	0.00'	TOC
01546	14.03'	15.14'	1.11'	TOC
01552	-	17.28'	-	TOC
01553	15.06'	16.57'	1.51'	TOC
01554	-	13.46'	-	TOC
01561	13.25'	13.25'	0.00'	TOC

TABLE 4

JUNE 29, 1989 LNAPL THICKNESS

<u>Well No.</u>	<u>Depth to NNAPL</u>	<u>Depth to Water</u>	<u>LNAPL Thickness</u>	<u>Measuring Point</u>
01539	22.51'	22.51'	0.00'	TOC
01540	15.14'	15.14'	0.00'	TOC
01543	13.83'	13.83'	0.00'	TOC
01544	14.32'	14.32'	0.00'	TOC
01545	15.32'	15.32'	0.00'	TOC
01546	15.00'	16.20'	1.20'	TOC
01552	13.36'	13.36'	0.00'	TOC
01553	15.66'	17.09'	1.43'	TOC
01554	13.20'	13.20'	0.00'	TOC
01561	14.38'	14.38'	0.00'	TOC
01574*	14.48'	14.49'	0.01'	TOC
01575*	15.21'	15.34'	0.13'	TOC

\* Installed and developed 06/20/89 - 06/22/89.

TABLE 5

JULY 11, 1989 LNAPL THICKNESS

<u>Well No.</u>	<u>Depth to NNAPL</u>	<u>Depth to Water</u>	<u>LNAPL Thickness</u>	<u>Measuring Point</u>
01539	22.73'	22.73'	0.00'	TOC
01540	15.28'	15.28'	0.00'	TOC
01543	14.05'	14.05'	0.00'	TOC
01544	14.57'	14.57'	0.00'	TOC
01545	15.55'	15.55'	0.00'	TOC
01546	15.30'	16.60'	1.30'	TOC
01552	18.08'	18.08'	0.00'	TOC
01553	15.92'	17.33'	1.41'	TOC
01554	13.36'	13.36'	0.00'	TOC
01561	14.71'	14.71'	0.00'	TOC
01574	14.77'	14.77'	0.00'	TOC
01575	15.52'	15.67'	0.15'	TOC

lack of LNAPL in these wells may result from the well construction, rather than the actual absence of LNAPL in these areas.

It is believed that the LNAPL present in Well 01553 resulted from lowering the water level below the top of screen during the sampling process in Spring 1988. Pumping the well prior to sampling created a drawdown in the water table that allowed the LNAPL to flow into the well. The surrounding Shell wells were sampled during the same time period. Thus, if LNAPL were present it would have flowed into these wells also. The lack of detectable LNAPL in the existing Shell wells probably indicates a lack of LNAPL in the vicinity of these wells.

The theory of drawdown of the water level resulting in the presence of LNAPL in Well 01553 can be confirmed by comparing the pre-sampling thickness with the post-sampling thickness of LNAPL. The well was sampled on June 13, 1989. A thickness of 1.62 feet was noted prior to sampling. A thickness of 1.41-1.48 feet was measured during the days following sampling. The original thickness of LNAPL has not recovered as of July 11, 1989. In contrast, the top of screen in Well 01546 extends above the water table. This well was also sampled on June 13, 1989. A comparison of the pre-sampling and post-sampling thicknesses indicates that the original thickness has recovered.

### 3.3 LNAPL SAMPLING AND ANALYSES

Results generated from the analyses of the LNAPL samples are presented as Table 6. The sample numbers correspond to the well sampled, and the duplicate sample is designated by a "D" following the sample number.

The samples were analyzed by adding 2500 ppm of Toluene-d8 as an internal standard. The sample was injected neat into a Hewlett-Packard 5980 gas chromatograph utilizing a 30M DB-5 column held

**TABLE 6****RESULTS OF LNAPL SAMPLE ANALYSES**

<u>Compound</u>	<u>% of Total</u>		
	<u>01546</u>	<u>01553</u>	<u>01553D</u>
Benzene	0.17	1.7	2.1
BCHD	0.13	0.32	0.37
Toluene	0.54	1.6	2.0
Xylene	0.83	1.0	1.3
Substituted BCHD	2.0	1.7	2.2
DCPD	4.1	3.7	4.3
DCPD (others)	5.3	5.8	7.0
DCPD +2	6.7	5.9	7.4
DCPD +14, +28	34.9	36.4	41.4
TCPD	7.1	9.3	10.4
unidentified	38.23	32.58	21.53

BCHD = Bicyclo[2.2.1]hepta-2,5-diene

DCPD = Dicyclopentadiene

DCPD (others) = Compounds with mass spectra similar to DCPD but with different retention times.

DCPD + 14, + 28 = Compounds similar to DCPD but with one or two additional methyl groups.

TCPD = speculated tricyclopentadienes

Quantitation based on Toluene-d8 as internal standard. Response factors for benzene, BCHS, toluene, p-xylene, and DCPD based on authentic samples. All others use the response factor of a related compound.

initially at 40°C and ramped at 8°C per minute to 310°C with a split ratio of approximately 40 to 1 and an injection port temperature of 275°C. The H-P GC was interfaced to a VG Trio-1 mass spectrometer scanning over a 35-450 amu mass range at a rate of once per second.

The results indicate that the LNAPL is comprised primarily of a complex mixture of hydrocarbons apparently derived from dicyclopentadienes and bicycloheptadienes. In addition to the "dienes", benzene, toluene, and xylene comprise from 0.1 to 2.0 percent of the LNAPL, while 21 to 38 percent consists of compounds that are unidentified due to their presence on the mass spectrograph being overshadowed by the identified compounds.

Given the composition of the LNAPL plume, a comparison of the configuration of this plume can be made to those of each primary contaminant occurring in the dissolved phase near tanks 464A and 464B. By comparing the configurations of the bicycloheptadiene and dicyclopentadiene dissolved plumes developed from 1988 data with the configuration of the LNAPL plume measured in 1989, there appears to be a good correlation in location between the separate-phase and dissolved phase.

#### 4.0 CONCLUSIONS

- The LNAPL plume is an active source of contamination to the groundwater.
- The current investigation has partially defined an LNAPL plume that has a maximum apparent thickness measured in monitoring wells of 1.41 feet, with a limited lateral extent.
- With respect to identified compounds, the LNAPL is primarily comprised of dicyclopentadiene and bicycloheptadiene derivatives with minor percentages of xylene, benzene, and toluene.
- Based on hydrogeologic and water-quality information and the presence of LNAPL, it is reasonable to assume that LNAPLs are present in the unsaturated and saturated zones beneath and in the vicinity of Tank 464A.
- The LNAPL plume is restricted to the Denver Formation sediments.
- Considering the extent of contamination in the dissolved phase and the location and composition of the LNAPL plume, it appears that the plume serves as a source of dissolved plumes.



## 5.0 RECOMMENDATIONS

The presence of the LNAPL plume adjacent to Tank 464A will probably result in contamination of groundwater downgradient of the site over an increasingly wide area within Sections 1 and 2. Ultimately, the LNAPL, groundwater, and other contaminated resources will have to be remediated, and dispersal of contaminants over an increasingly large area at increasing concentration levels will likely drive up the cost of remediation. Therefore, an interim response action on the LNAPL plume may be cost-effective.

From consideration of the issues stated above, it is recommended that the LNAPL plume be considered an integral part of the South Tank Farm Plume, as one of potentially several sources of contamination to groundwater in Sections 1 and 2. Furthermore, the LNAPL plume should be considered in addition to the dissolved plume in the development of remedial alternatives for the South Tank Farm Plume under the Remediation of Other Contamination Sources IRA.

**APPENDIX A**

Borehole/Well No. : C1543Project/Task No's. : 1660/37030101Date Started : 5/25/89Date Completed : 5/25/89Drilling Inspector : Bill CarterDrilling Company : Screw Drilling

## Surveyed

Location : N 178159.479  
E 2184429.721

## Surveyed

Elevation : GS 5266.06 ft.  
TOC 5267.94 ft.Total Depth Drilled : 26.5 ft. <sup>4 GND 7-27-89</sup>Drilling Type : Hollow Stem AugerStatic Water Level Depth : 14.55 ft.  
below TOC

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
5							
10							
15							
20							
25							

CONTINUOUS SAMPLING w/ 5" Split Barrel

Steel Protective casing  
2" Dia PVC Casing

CONCRETE

Grout

4' Bentonite

6.3' 10/20 Sand

2" Dia PVC 0.02" Slot Screen

Ground Surface

Brown, sandy clayey silt, moist  
Top of Denver @ 3.5'

siltstone; clayey, tan to greenish brown, weathered moist

claystone; brown; sandy to silty, highly fractured blocky structure, green, -> at 5.0'-5.4' and 6.3'-6.7' Highly weathered, moist



claystone; brown; silty to sandy w/ depth; highly weathered, moist

siltstone; light to dark gray; clayey to sandy; moderately weathered; 1"-3" thick sandstone; silty; interbeds moist

siltstone; gray to brown; sandy, clayey; moderately weathered; variegated streaked (stratification)

siltstone; moist gray to brown; sandy, clayey, silty; weathered; minor fracturing

Borehole/Well No. : C1543Project/Task No's. : 1680/3703.01.01Date Started : 5/25/89Date Completed : 5/25/89

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
24 30		Continuous Sampling w/ 6' Split Barrel	20.5		2" Dia PVC 6.02" 46t screen Threaded bottom plug #10-20 sand		Claystone; dark gray to greenish gray; <del>is</del> slightly weathered; brittle, moist  NOTE: The reduced sample recovery is probably due to compaction of the sample.

Borehole/Well No. : 1546Project/Task No's. : 1680/3703.01.01Date Started : 5/26/89Date Completed : 5/26/89Drilling Inspector : C. AllenDrilling Company : Arrow Drilling

## Surveyed

Location : N 178076.074E 2184384.326

## Surveyed

Elevation : GS 5265.81 ft.TOC 5268.30 ft.Total Depth Drilled : 28.15 ft.Drilling Type : Hollow Stem AugerStatic Water Level Depth : 16.10 ft.below TOC

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
0							
0					Steel Protective casing		
0					2" Dia PVC casing concrete		
0					Grout		
2.8			64%		5' Bentonite		
7.2			50%		7' 10/20 Sand Top of Screen @ 7.2'		
10			50%		8' 10/20 Sand		
15			60%		2" Dia, PVC, 0.02" slot screen		
20			50%				
25							

CONTINUOUS SAMPLING  
w/ 5' Split Barrel

## Ground Surface

Med brown, clayey, silty, sand, slightly moist

Top of Denver @ 2.8'

Claystone; slightly green to med brown; silty, sandy; weathered; friable; fractured slightly moist

Claystone; Dark green to med brown; sandy w/ lithic clasts to 4mm, two 1" thick claystone; green; blocky, lenses approx 1' apart in interval; internal highly weathered, highly fractured moist

Claystone; med to dark brown; sandy w/ 10-15% lithic clasts up to 5mm; weathered; friable; fractured, moist

Siltstone; med brown; clayey, sandy; 1/4" thick bedded planes (clastic) weathered - Product on material moist

Claystone; Green to med brown; silty, sandy, moist weathered; blocky structure; Product on material

Borehole/Well No. : C1546Project/Task No's. : 1680/3203.0101Date Started : 5/26/89Date Completed : 5/26/89

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
28			100%		2" Dia, PVC Casing slot screen Threaded bottom plug # 10/20 Sand  Bottom of Screen @ 27.2'		claystone; red brown; silty, sandy; 10% lithic fragments to 1.5 mm.; Production material Siltstone; green to red brown; sandy; weathered and hard; Production material  NOTE: The reduced sample recovery is probably due to compaction of the sample. Also, during well construction a yellow greenish brn oily product pooled <sup>around</sup> the auger @ 25'-30'. As <sup>the 20-25'</sup> auger was being pulled, the product turned viscous and a darker brown.
CONTINUOUS SAMPLING W/ 5' SPLIT BARREL							

Borehole/Well No. : C1561Project/Task No's. : 1650/3703-01.01Date Started : 5/30/89Date Completed : 5/30/89Drilling Inspector : C. AllenDrilling Company : Arrow Drilling

## Surveyed


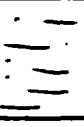
Location : N 178049.591  
E 2184409.705

## Surveyed

Elevation : GS 5265.99 ft.  
TOC 5267.54 ft.Total Depth Drilled : 28.1 ft.Drilling Type : Hollow Stem AugerStatic Water Level Depth : 14.01 ft.Below TOC

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
0							
0.6'				Steel Protective Casing 2" Dia. PVC Casing			
3.7'			80%	Grout			Fill
5.4'			100%	Bentonite			Med brown silty sand Tan mottling, slightly moist Top of Denver @ 3.7'
7.0'			70%				claystone; green to med brown; sandy, increased sand content w/ depth; highly weathered; minor fracturing
8.1'							
			70%	2 10/20 Sand			claystone; light green; sandy, silty; weathered; no obvious fracturing; minor iron staining in lower 4" moist
			60%	2" Dia. PVC 0.02" Slot Screen			siltstone; light to med brown; sandy; weathered; lower 3"; claystone; light green to med brown; sandy; fractured, moist
			70%				claystone; med brown; sandy; weathered; highly fractured; minor blocky structure, moist

Borehole/Well No. : 51561Project/Task No's. : 1680/2203.0101Date Started : 5/30/89Date Completed : 5/30/89

Sample Information					Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description	
30		CONTINUOUS SAMPLING w/ 5' SPLIT BARREL	100%		2" Dia, PVC 0.02" slot screen Threaded bottom plug # 10/20 sand  Bottom of Screen @ 28.1		<u>claystone</u> ; med brown; sandy w/ lithic clasts; slightly weathered; highly fractured  NOTE: The reduced sample recovery is probably due to compaction of the sample.	



Borehole/Well No. : C1545 Project/Task No's. : 1680/3703.01.01

Date Started : 5/30/89 Date Completed : 5/31/89

Drilling Inspector : C. Allen

Drilling Company : Trew Drilling

**Surveyed**

Location : N 178102.769  
E 2184359.043

**Surveyed**

Elevation : GS 5267.32 ft.  
TOC 5268.98 ft.

Total Depth Drilled : 28.2 ft. Drilling Type : Hollow Stem Auger

Static Water Level Depth : 15.93 ft.  
Below TOL


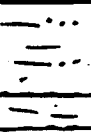
Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
0				Steel Protective Casing			
0.6				2" Dia PVC casing			
0.6				Concrete			
0.6				Grout			
5.1				Bentonite			
6.6							
8.2							
10				10/20 Sand			
15				2" Dia PVC			
20				0.02" slot screen			
28.2							

CONTINUOUS SAMPLING  
w/ 5' SPLITSPR

**Ground Surface**

Sandy Fill, moist  
Dark brown, silty, sandy clay - clay interval  
to moist  
Med brown, very fine to very coarse  
silty sand, moist  
Top of Denver @ ~5.5'  
Claystone; olive green to med brown;  
silty, ~~moist~~ dry.  
  
Siltstone; med brown; clayey, sandy;  
weathered, dry  
  
Siltstone; med brown; clayey, sandy;  
highly weathered, slightly  
moist  
  
Siltstone; med brown; clayey, sandy;  
w/ 5% lith clasts to 4mm;  
highly weathered, moist

Borehole/Well No. : 1545Project/Task No's. : 1680/3203.01.01Date Started : 5/30/89Date Completed : 5/31/89

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
			80%		2" Dia PVC 0.02" slot screen # 10/20 sand Threaded bottom plug  Bottom Screen @ 28.2		<u>Siltstone</u> ; med brown, clayey, sandy; highly weathered; lower one foot of interval = <u>claystone</u> ; light green to med brown; sandy; weathered; fractured  NOTE: The reduced sample recovery is <sup>possibly</sup> probably due to compaction of the sample.
CONTINUOUS SAMPLING w/ 5' SPLIT SPOON							

Borehole/Well No. : 1544Project/Task No's. : 1680/5203.cic1Date Started : 5/31/86Date Completed : 5/31/86Drilling Inspector : C. AllenDrilling Company : Arrow Drilling

## Surveyed

Location : N 178116.479  
E 2184400.577

## Surveyed

Elevation : GS 5266.55 ft.  
TOC 5266.37 ft.Total Depth Drilled : 28.3 ft.Drilling Type : Hollow Stem AugerStatic Water Level Depth : 15.40 ft.below DC

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
					Steel Protective casing 2" Dia PVC casing 0.5' CONCRETE		
					Grout		<b>Ground Surface</b> Med brown sandy, clayey, silt, moist Top of Denver @ 3.6'
			100%		5.4' Sandstone 7.0'		claystone; med brown; sandy; Highly weathered; Friable; blocky
			55%		5.0'		claystone; slightly red to med brown; silty, sandy; Highly weathered; Friable, moist
			50%		3 10/20 sand		claystone; slightly red to med brown; silty, sandy; Highly weathered; Friable; lower one foot contains two 2" thick lenses of claystone; light green; sandy
			50%		2" Dia PVC 0.02" slot screen		siltstone; med brown; clayey, sandy; weathered; moderate fracturing; product on material, moist
			60%				siltstone; slightly red to med brown; sandy, clayey; weathered; minor fracturing; minor product on material, moist

Borehole/Well No. : C15441Project/Task No's. : 1680/15013.C141Date Started : 5/31/89Date Completed : 5/31/89

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
		CONTINUOUS SAMPLING w/ 5' SPIT SCREEN	100%		2" Dia PVC C.C.2" slot screen 10/20 sand threaded bottom plug		claystone; slightly red to red brown; sandy; weathered; fractured moist siltstone; slightly red to red brown; sandy, clayey; <10% lithic fragments; weathered; blocky structure; product on material  NOTE: The reduced sample recovery is probably due to compaction at the sample.

Borehole/Well No. : 01575Project/Task No's. : 1680/137030101Date Started : 6/21/89Date Completed : 6/21/89Drilling Inspector : C. AllenDrilling Company : Green Drilling

## Surveyed

Location : N 174093.147

## Surveyed

Elevation : GS 5267.29 ft.E 2124405.213TOC 5269.05 ft.Total Depth Drilled : 28 ft.Drilling Type : Hollow Stem AugerStatic Water Level Depth : 15.52' ft.Below TOC

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
0							
5							
10							
15							
20							
25							
NO SAMPLES - SEE LOG OF 01562					Steel Protective Casing		
					2" Dia PVC Casing		
					Concrete 0.5'		Ground Surface
					Grout		SEE LOG OF BORING 01562
					5.0'		NOTE: Well 01575 is located about 4.5' north of abandoned well 01562.
					Benbrink 7.5'		
					8.0'		
					5 10/32 Sand		
					2" Dia PVC 0.02" S/G Screen		

Borehole/Well No. : 2152Project/Task No's. : 160 / 1000.0101Date Started : 6/2/89Date Completed : 6/2/89

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
					2" Dia PVC 0.02" slot screen 28.0' sand Thru sand bottom 1.25'		SEE LOG OF BORING #C1062

Borehole/Well No. : 01562 \*\*Project/Task No's. : 1660/3030101Date Started : 6/20/89Date Completed : 6/21/89Drilling Inspector : C. AllenDrilling Company : Arrow Drilling

## Surveyed

Location : N 174089.443

## Surveyed

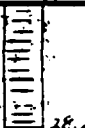
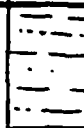
Elevation : GS 5267.18 ft.E 2184405.383

TOC \_\_\_\_\_ ft.

Total Depth Drilled : 28.2 ft.Drilling Type : Hollow Stem AugerStatic Water Level Depth : NA ft.

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
							** Well 01562 Abandoned, Replaced with Well 01575
							Gravel Fill
							Ground Surface
5			60%		Gravel *		Sand; med brown; very fine to med. grained, dry Top of Denver @ 4.0'
10			60%		Bentonite		Siltstone; med brown; sandy w/ minor clay; highly weathered; no fracturing; friable; 10% lithic fragments to 1/4" dia slightly moist
15			70%		70/20 Sand		Siltstone; slightly red to med brown; sandy; highly weathered; no fracturing
20			60%		2" Dia PVC 0.02" Slot Screen		Claystone; upper 0.5' med brown; sandy; highly weathered - friable middle 1.0' - claystone; light brown
25			70%				siltstone; slightly red to med brown; sandy; highly weathered - friable; 10% lithic fragments
							SAME AS ABOVE w/ minor claystone interbeds

Borehole/Well No. : 31-62Project/Task No's. : 140/323.010Date Started : 2/20/80Date Completed : 2/21/80

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
30		CONTINUOUS SAMPLING w/ 5' SPLIT SCREEN	100%	 28.2'	#10 Sand 2" Dia PVC 0.02" Slot Screen threaded bottom plug		Claystone; reddish green to mud brown; silty, sandy; fairly weathered. Friable; 15% thin fragments to 1/2" in size  * well obstructed - Appears that well collapsed and sand in filled hole while emplacing sand pack. Pulled upper broken casing (12'), then grouted the remaining annular space (hole). Moved 4.5' north and drilled new well 01575.  NOTE: The reduced sample recovery is probably due to compaction of the sample.



**Project/Task No's. :** 1690 / 3202.01.01

**Date Started :** 6/20/99

**Date Completed :** 6/20/89

**Drilling Inspector :** C. Allen

**Drilling Company :** Arcon Drilling

## Surveyed

Location: N 178061.112

E 2184366.533

## Surveyed

**Elevation :** GS 5266.64 ft.

TOC 5267.55 ft.

**Total Depth Drilled:** 29.0' ft.

Drilling Type : Hollow Stem Auger

**Static Water Level Depth :** 141.2 ft.

Below TOC


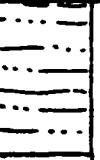
Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
0							<p><b>Ground Surface</b> Top of Denver @ 3.6'</p> <p><u>Silty sand</u>; slightly moist; med brown very fine to coarse grained <u>claystone</u>; clark to med brown; sandy; highly weathered w/ Tan nodules, minor fracturing</p> <p><u>claystone</u>; green to reddish brown; sandy, silty; highly weathered; highly fractured; minor blocky structure</p> <p><u>Siltstone</u>; slightly red to med brown; sandy w/ minor clay; highly weathered; highly fractured</p> <p><u>claystone</u>; moist; light green to med brown; sandy; highly weathered; highly fractured; friable; minor blocky structure</p> <p><u>Siltstone</u>; moist; light red to med brown; sandy w/ minor claystone interbeds; highly weathered; highly fractured; friable</p>

Borehole/Well No. : C1574

Project/Task No's. : 1680/3203-019

Date Started : 6/20/89

Date Completed : 6/20/89

Sample Information				Well Construction		Subsurface Information	
Depth Below Ground Surface (ft.)	Blow Count/ Feed Pressure	Sample Type	Sample Depth/% Recovery	Well Schematic	Material Description	Borehole Schematic	Lithologic and Hydrologic Description
30			90%		2" Dia PVC 0.02" Slot Screen 3 1/2" sand thinned bottom plug		Siltstone; moist; light red to red brown; sandy; moderately weathered; moderately fractured; two 3" thick lenses of claystone; green; blocky 2' apart 2' down from top of interval; minor product on material  NOTE: The reduced sample recovery is probably due to compaction of the sample.